Heavy Vehicle Propulsion Materials

Development of Materials Analysis Tools for Studying NO_x Adsorber Catalysts

Background

In order to meet the 2007 emission requirements for diesel exhaust, engine aftertreatment will be needed. The necessary technology will need to integrate aftertreatment with engine control systems. Currently, no commercial off-the-shelf technologies are available to meet the 2007 standards. Consequently, Cummins, Inc., is working to understand the basic science necessary to effectively utilize these catalyst systems. The Oak Ridge National Laboratory (ORNL) is assisting Cummins with the materials characterization effort.

Technology

Base-metal oxides (BMOs) are major components in current NO_x adsorber catalysts which Cummins seeks to use in aftertreatment systems. Although the function of these adsorbers is to collect surface nitrite/nitrate (NO_x) species, they also collect oxy-sulfur (SO_x) species. Both species are to be released from these surface sites during different regenerations, where the adsorber BMO is either heated to some critical temperature and/or exposed to a reducing or reactant atmosphere. Sulfur adsorption is unfortunately a form of poisoning to adsorber catalysts. It is a major problem that must be resolved before BMO-based emission reduction technologies become commercially viable.

Status

The crystal structure, morphology, phase distribution, particle size and surface species of catalytically active materials supplied by Cummins will be characterized using X-ray diffraction (XRD), Raman spectroscopy, and electron microscopy. These materials will come from all stages of the catalyst's life cycle: raw materials, as-calcined, sulfated, regenerated, etc.

Pt is the catalytically active element which must remain dispersed and of small size within the adsorber. Past work has shown Pt particle growth

Figure 1. *A Cummins ISX engine.*

Benefits

- Addresses a major technical barrier to long-term viability of NO_x adsorber catalyst.
- Assists heavy-duty diesel engines in meeting 2007 requirements for NO_x emissions.

as a function of desulfation time in lab-based engine tested samples. Last year, evaluation of gradient formation of active elements on a macro scale was investigated on catalysts.

A scanning transmission electron microscope (STEM) was employed to examine the gradient of Pt particle size along the length of a catalyst sample taken from a cordierite "brick." Figure 2 shows the Pt particle sizes to be the same at both ends of the sample. The bright spots in the STEM images are the Pt particles. Multivariate statistical analysis, an analysis procedure for spectral image datasets, was applied to extract the particle size distribution from 10 images of each section. While the distributions appear to be different, the average and median sizes are effectively the same. The XRD results also showed negligible particle/crystallite size change along the length of the sample, but did not agree with respect to size. Superposition of the Pt and washcoat peaks will require synchrotron XRD to resolve.

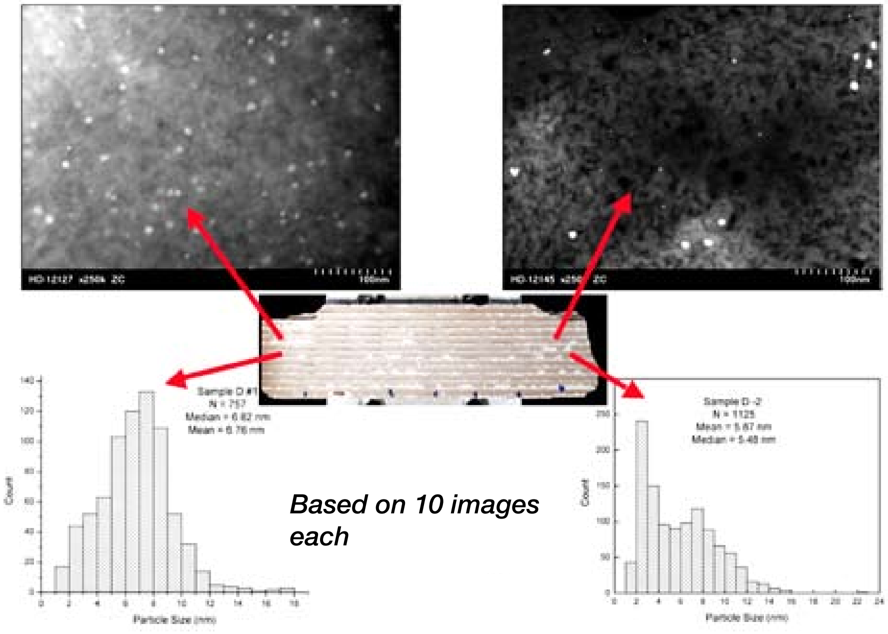

Figure 2. *HA-ADF image from the STEM showing Pt particles in bright contrast and the corresponding size distributions.*

Contacts

Dr. Thomas Watkins
Oak Ridge National Laboratory
(865)574-2046
watkinstr@ornl.gov

Dr. James Eberhardt
DOE Technology Manager
Department of Energy
(202) 586-9837
james.eberhardt@ee.doe.gov